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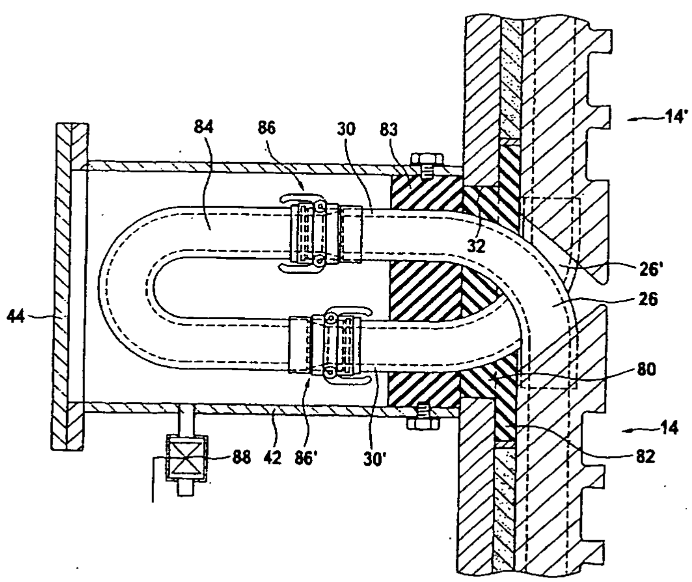
(54) Title: COOLED FURNACE WALL



(57) Abstract: A cooled furnace wall comprises a furnace shell with an inner and an outer side and cooling plates (14, 14') lining the inner side of said furnace shell. Each of the cooling plates (14, 14') has a plate body (20, 20') and protruding connection pieces for supplying the cooling plate (14, 14') with a coolant. The furnace shell has connection openings therein for interconnecting the connection pieces of adjacent cooling plates (14, 14') from the outer side of said furnace shell. At least one of the connection pieces is formed by a tube bend (26, 26') that protrudes from an edge face (18, 18') of the plate body (20, 20') and that has a connection end (30, 30') to extending through one of the connection openings in the furnace shell.

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Cooled furnace wall

Technical field

[0001] The present invention generally relates to a cooled furnace wall. It relates more particularly to a furnace wall comprising a furnace shell with an inner side and an outer side and cooling plates lining the inner side of the furnace shell. Each of these cooling plates has a plate body with protruding connection pieces for a coolant. The furnace shell has connection openings therein, which enable to interconnect the protruding connection pieces of adjacent cooling plates from the outer side of the furnace shell.

Background Art

[0002] It is well known to line the inner side of a furnace shell of a metallurgical furnace, in particular a blast furnace, with cooling plates. Such a cooling plate, also called "stave", comprises a rectangular, solid plate body with cooling passages therein. Connection pieces, which protrude from the rear side of the cooling plate, debouch into the cooling passages of the cooling plate. These connection pieces are led in a sealed manner through connection openings in the furnace shell. At the outer side of the furnace shell, flexible metal tubes are used to interconnect the connection pieces of adjacent cooling plates and to connect the cooling plates to a cooling water distribution circuit.

[0003] The plate body of such a cooling plate is made either from cast iron (in particular modular cast iron) or from copper or a copper alloy, or more recently also from steel. In cooling plates made from cast iron, the cooling passages are generally formed by cast-in U-shaped steel tubes, wherein the ends of a cast-in tube protrude from the rear side of the plate body as connection pieces. In virtually all cooling plates made from copper or steel, however, the cooling passages are directly formed in the solid cooling plate body.

[0004] DE 2 907 511 discloses a cooling plate which is made from a forged or rolled block of copper. The cooling passages in the copper block are blind bores produced by mechanical deep-drilling. The openings of these blind bores are sealed off by soldering or welding plugs therein. Connecting bores are drilled from

Technical solution

[0009] According to a first aspect of the present invention, this object is achieved through the fact that a connection piece of a cooling plate is formed by a tube bend that protrudes from an edge face (i.e. a narrow side face) of the plate body and that has a connection end extending through one of the connection openings in the furnace shell. A connection piece of this type may, for example, be formed by a 90° tube bend, a first end of which is inserted into an opening of a cooling passage in the edge face of the plate body. In other words, the connection piece no longer opens perpendicularly through the rear side of the cooling plate body into the cooling passage, but rather in axial extension of the cooling passage through an edge face of the cooling plate body. The cooling fluid is consequently diverted within the tube bend connection piece itself, which causes relatively low pressure losses.

[0010] It will also be appreciated that production of a cooling plate with cooling passages formed directly in a solid plate body is significantly simplified by the present invention. In fact, the openings of the cooling passages in the edge faces of the cooling plate body no longer have to be sealed by soldering or welding plugs therein, and there is also no need to drill separate connection passages for the connection pieces from the rear side of the cooling plate. In the process which is known from DE-A-2907511, the blind bores can be replaced by through-bores, which simplifies cleaning of the drilled cooling passages. Moreover, dead end sections (i.e. passage end sections through which there is no flow), in which sand, weld beads and rust particles normally accumulate and/or air pockets or vapour bubbles form, are avoided, which will result in an improved cooling capacity and service life of the cooling plates. Also the cooling of the bottom and top ends of the cooling plates is significantly improved, since the cooling medium now flows directly through these top and bottom ends.

[0011] Cooling plates with cooling passages directly formed in a solid plate body may, for example, comprise a continuously cast cooling plate body made from copper or a copper alloy with cast-in cooling passages, a forged or rolled cooling plate body made from copper or a copper alloy with drilled or milled cooling passages, or a cooling plate body made from steel with drilled or milled cooling

[0016] To reduce the distance between the edge faces of two adjacent cooling plates, the second ends of the tube bends of the first cooling plate and the second ends of the tube bends of the second cooling plate may be arranged in a row. In this case, the flexible connection means may, for example, comprise a bent tube segment which is arranged in the connection box and is substantially in the shape of racing cycle handlebars. A shape of this type ensures the required resilience to absorb differential movements of the cooling plates.

[0017] As an alternative solution to a connection box, the connection opening in the furnace shell may for example be covered by a socket piece. The latter has for each connection end a separate through-opening, and each of these connection ends is connected in a sealed manner to the socket piece by means of a compensator.

[0018] In order to protect the tube bends with respect to the interior of the furnace, a plate extension may be arranged in front of the tube bends at the edge face of the cooling plate.

[0019] If there are two rows of cooling plates arranged directly vertically above one another, the vertical joins between the cooling plates belonging to the upper row may be offset relative to the vertical joins between the cooling plates belonging to the lower row. In this arrangement, the tube bends of a cooling plate belonging to the lower row can be connected to the tube bends of two adjacent cooling plates belonging to the upper row.

[0020] The edge face of the plate body from which the connection pieces protrude is advantageously bevelled towards the inner side of the furnace shell. This allows two cooling plates which are to be connected by means of their connection pieces to be arranged significantly closer together. Furthermore, the bent connection pieces lie in the shadow of the bevelled cooling plate edge and are therefore at least partially protected from heat radiation from the furnace interior. If two cooling plates are to be connected, the opposite edge faces from which the connection pieces protrude are advantageously bevelled in a mirror image, so that they delimit a wedge-shaped space which narrows towards the interior of the furnace.

Brief Description of Drawings

[0024] Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:

Fig. 1: is a longitudinal section through a first embodiment of a cooled furnace wall;

Fig. 2: is a longitudinal section through a second embodiment of a cooled furnace wall;

Fig. 3: is a plan view of a first arrangement of cooling plates in an embodiment of a cooled furnace wall;

Fig. 4: is a plan view of a second arrangement of cooling plates in an embodiment of a cooled furnace wall;

Fig. 5: is a plan view of a third arrangement of cooling plates in an embodiment of a cooled furnace wall;

Fig. 6: is a longitudinal section through a third embodiment of a cooled furnace wall;

Fig. 7: is a longitudinal section through a first variant of the embodiment shown in Fig. 6;

Fig. 8 is a longitudinal section through a second variant of the embodiment shown in Fig. 6;

Fig. 9: is a longitudinal section through a third variant of the embodiment shown in Fig. 6;

Fig. 10: is a longitudinal section through a fourth embodiment of a cooled furnace wall;

Fig. 11: is a longitudinal section through a first variant of the embodiment shown in Fig. 10;

Fig. 12: is a longitudinal section through a fifth embodiment of a cooled furnace wall;

Fig. 13: is a longitudinal section as in Fig. 6, with further details;

Fig. 14: is a plan view of a connection box in which connection pieces of two cooling plates are connected to one another; and

Fig. 15: is a plan view of an arrangement of cooling plates with connection boxes in accordance with Fig. 14;

Fig. 16: is a three-dimensional view of a first embodiment of a turbulator to be

referred to as connection end 30') of the upper tube bend 26' faces the same connection opening 32 in the furnace shell 12. In this arrangement, the two tube bends 26 and 26' lie vertically above one another in the free space which is formed between the upper edge face 18 of the lower cooling plate 14 and the lower edge face 18' of the upper cooling plate 14'. To shield the free space 34 in which the tube bends 26 and 26' are located with respect to the interior of the furnace, a plate extension 36, 36' is arranged both at the upper edge face 18 of the lower cooling plate 14 and at the lower edge face 18' of the upper cooling plate 14', in each case towards the interior of the furnace.

[0028] In the embodiment shown in Fig. 1, the lower tube bend 26 is connected to the upper tube bend 26' by means of a compensation tube bend 40, the compensation tube bend 40 being welded to the free ends 30, 30' of the tube bends 26, 26'. This compensation tube bend 40 passes the cooling medium (generally cooling water) out of the cooling passage 20 into the cooling passage 20', wherein its resilience in the vertical direction compensates for temperature-related changes in the distance "D". The compensation tube bend 40 projects into a connection box 42 which is arranged on the outer side of the furnace shell 12 over the connection opening 32 in the furnace shell 12. This connection box 42 is connected in a gastight manner to the furnace shell 12 and is likewise closed off in a gastight manner by means of a removable blind flange 44. After removal of the blind flange 44 one has direct access to the compensation tube bend 40 from the outer side of the furnace shell 12.

[0029] In the embodiment shown in Fig. 2, extended connection ends 46, 46' of the tube bends 26, 26' are led in a sealed manner out of the furnace shell 12. For this purpose, the connection opening 32 in the furnace shell 12 is covered by a socket piece 48 which forms a passage 49, 49' for each connection end 46, 46'. Each connection end 46, 46' is in this case connected in a sealed manner to the socket piece 48 by means of a compensator 50, 50'. The compensators 50, 50' (bellows compensators are illustrated in Fig. 2) must be designed so as to be able to absorb lateral and angular movements of the connection ends 46, 46'. A common protective housing 52 surrounds the two compensators 50, 50'. In the embodiment shown in Fig. 2, the connection ends 46, 46' will be interconnected,

cooling plates on the right-hand side of Fig. 5, the tube bends 26, 26' are connected by means of metal hoses 62.

[0033] Fig. 6 shows a further embodiment of the cooled furnace wall. In this embodiment, the two edge faces 18, 18' of the cooling plates 14, 14' out of which bent connection pieces 26, 26' are led out of the plate bodies 20, 20' are bevelled in mirror-image fashion towards the inner side of the furnace shell 12, in such a manner that they delimit a wedge-shaped space 69 which narrows towards the interior of the furnace. The angle α between the respective rear side of the cooling plate 14, 14' and the corresponding edge face 18, 18' is advantageously in the range from 105° to 150° and is preferably 120°. In the wedge-shaped space 69, the bent connection pieces 26, 26' are substantially shielded from the thermal radiation from the interior of the furnace. They are located, so to speak, in the shadow of the edges of the cooling plates 14, 14'. Moreover, the wedge-shaped space 69 may be filled with a refractory material, in which case, however, the expansion of the cooling plates 14, 14' and their connection pieces must not be excessively impeded. Since the bent connection pieces 26, 26' are now relatively well protected from thermal radiation, they may also be made, for example, from stainless steel. In this context, it should be noted that tube bends made from stainless steel have better mechanical properties and lower prices than thick-walled tube bends made from copper.

[0034] Figure 7 shows a modification to the embodiment shown in Fig. 6. The two plate bodies 20, 20' are arranged vertically above one another on the inner side of the furnace shell. The edge face 18 of the lower plate body 20 has a nose-like projection 70 facing the interior of the furnace, which is bevelled parallel to the opposite edge face 18' of the upper plate body 20', so that this nose-like projection 70 and the edge face 18' of the upper plate body 20' form a gap 72 which slopes from the interior of the furnace upwards towards the inner side of the furnace shell 12. This gap 72 which rises upwards towards the inner side of the furnace shell 12 makes it more difficult, for example, for settling burden to penetrate into the wedge-shaped space 69.

[0035] Fig. 8 shows a modification to the embodiment shown in Fig. 7. The edge face 18' of the upper plate body 20' has a nose-like projection 70' facing the

furnace shell 12 can be reduced, for example, by a constriction in the furnace shell (not shown).

[0039] Fig. 12 shows a further embodiment of the cooled furnace wall. Both the lower cooling plate 14 and the upper cooling plate 14' comprise a plate body 20, 20' made from cast iron in which the cooling passages are formed by cast-in tubes 76, 76'. The edge face 18, 18' is in each case partially bevelled at the rear, the tube bend 26, 26' emerging from the edge face which is bevelled towards the rear.

[0040] Fig. 13 shows a cooling plate arrangement as in Fig. 6 with further design details. It can be seen that a plug 80 with through-openings for the connection ends 30, 30' of the bent connection pieces 26, 26' has been inserted into the connection opening 32 in the furnace shell 12. The plug 80 consists of an elastic material, so that it does not significantly impede the free expansion of the connection pieces 26, 26' and cooling plates 14, 14'. At its edge, it has an encircling securing flange 82 which is clamped between the cooling plates 14, 14' and the furnace shell 12. The connection ends 30, 30' are guided through the through-openings in the plug 80 into the connection box 42, where they are connected to one another by means of a flexible connection line 84 with quick-acting couplings 86, 86'. Immediately behind the plug 80, a partial section of the connection box 42 is filled with a foamed elastic material 83 around the connection ends 30, 30'. The rear end of the connection box 42, which is not filled with foam and in which the connecting line 84 is arranged, has a leak-test valve 88 at its lowest point. In the event of a leak in the connections between the connection pieces 26, 26', cooling water collects in the rear end of the connection box 42. The leak-test valve 88 can be used to check the connection box 42 for the presence of leakage water without the blind flange 44 of the connection box 42 having to be opened.

[0041] Fig. 14 shows a plan view of a connection box 42 in which a plurality of connection pieces 26, 26' of two cooling plates 14, 14' are connected to one another. It can be seen that each of the bent connection pieces 26, 26', at the exit from the edge face 18, 18' of the plate body 20, 20', first of all has a first curvature 102, 102' in the mid-plane of the plate body 20, 20' (= plane parallel to the plane of the drawing) and then a second curvature 104, 104' in a plane which is

Claims

1. A cooled furnace wall comprising a furnace shell with an inner and an outer side and cooling plates (14, 14') lining said inner side of said furnace shell; each of said cooling plates (14, 14') having a plate body (20, 20') and protruding connection pieces for supplying said cooling plate (14, 14') with a coolant, and said furnace shell having connection openings therein that make it possible to interconnect the connection pieces of adjacent cooling plates (14, 14') from the outer side of said furnace shell; **characterized in that** at least one of said connection pieces is formed by a tube bend (26, 26') that protrudes from an edge face (18, 18') of said plate body (20, 20') and that has a connection end (30, 30') extending through one of the connection openings in said furnace shell .

2. The furnace wall according to Claim 1, wherein a connection end of a tube bend connection piece of a first cooling plate is connected by means of flexible connection means to a connection end of a tube bend connection piece of an adjacent second cooling plate.

3. The furnace wall according to Claim 2, wherein: a connection box is arranged on said outer side of said furnace shell above one of said connection openings; and said connection ends (30, 30') extend into said connection box where they are interconnected by means of said flexible connection means.

4. The furnace wall according to Claim 3, wherein said connection box is sealed off by means of a removable blind flange.

5. The furnace wall according to Claim 4, wherein said connection box is dimensioned so that one of said cooling plates (14, 14') can be removed from said furnace or introduced into said furnace through said connection box.

6. The furnace wall according to Claim 5, wherein adjacent connection openings in the furnace shell are vertically offset.

7. The furnace wall according to any one of Claims 3 to 6, wherein said flexible connection means comprises a compensation tube bend which is arranged in said connection box .

16. The furnace wall according to Claim 15, wherein said bevelled edge face (18, 18') forms an angle of approximately 120° with the rear side of said cooling plate.

17. The furnace wall according to Claim 14, 15 or 16, wherein for two cooling plates (14, 14') which are to be interconnected by means of said connection pieces (26, 26'), the opposite edge faces (18, 18') from which said connection pieces (26, 26') protrude are bevelled in a mirror image, so that they delimit a wedge-shaped space which narrows towards the interior of said furnace.

18. The furnace wall according to Claim 17, wherein: the plate bodies (20, 20') of said two cooling plates (14, 14') are arranged vertically directly above one another, so that an upper edge face of the lower plate body is directly facing a lower edge face of the upper plate body; and said upper edge face of the lower plate body has a nose-like projection which is bevelled parallel to said lower edge face of the upper plate body, so that said nose-like projection and said lower edge face of the upper plate body form a gap which slopes upwards towards said inner side of said furnace shell .

19. The furnace wall according to Claim 17, wherein: the plate bodies (20, 20') of said two cooling plates (14, 14') are arranged vertically directly above one another, so that an upper edge face of the lower plate body is directly facing a lower edge face of the upper plate body; and said lower edge face of the upper plate body has a nose-like projection which is bevelled parallel to said upper edge face of the lower plate body , so that said nose-like projection and said upper edge face of the lower plate body form a gap which slopes downwards towards said inner side of said furnace shell .

20. The furnace wall according to Claim 17, wherein the two bevelled edge faces (18, 18') each have a nose-like projection (70, 70') facing towards the interior of the furnace, and the two nose-like projections (70, 70') overlap.

21. The furnace wall according to any one of Claims 1 to 20, wherein said connection piece (26, 26') has at the outlet from said edge face (18, 18') a first curvature in a mid-plane of the plate body (20, 20') and thereafter a second curvature in a plane perpendicular to said mid-plane of said plate body (20, 20').

28. The furnace wall according to Claim 26 or 27, wherein:

on said outer side of said furnace shell , a connection box is arranged above said connection opening ;

at least two connection ends (30, 30') extend through said plug into this connection box, where they are interconnected by means of flexible connection means; and

a section of said connection box between said plug and said flexible connection means is sealed with a foamed sealing material.

29. The furnace wall according to Claim 27 or 28, wherein said connection box has a leak-test valve at its lowest point.

30. The furnace wall according to any one of Claims 1 to 29, wherein: a cooling plate has at least one cooling passage (22, 22') which is formed directly in a solid plate body (20, 20'); said cooling passage (22, 22') forms an opening (24, 24') in said edge face (18, 18') of said plate body (20, 20'); and

a first end (28, 28') of said tube bend (26, 26') is inserted into said opening (24, 24') in said edge face (18, 18').

31. The furnace wall according to Claim 30, further including a turbulator (200, 200') mounted in said cooling passage (22, 22'), wherein:

said turbulator includes a turbulator body (202, 202') and a ring-shaped fixing flange (204, 204');

said turbulator body (202, 202') is axially inserted into said cooling passage (22, 22');

said ring-shape fixing flange (204, 204') bears on a shoulder surface in said opening of said cooling channel; and

said ring-shape fixing flange (204, 204') is blocked on said shoulder surface by means of said first end (28, 28') of said tube bend (26, 26') that is inserted into said opening (24, 24') in said edge face (18, 18').

32. The furnace wall according to any one of Claims 1 to 29, wherein:

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Fig. 1

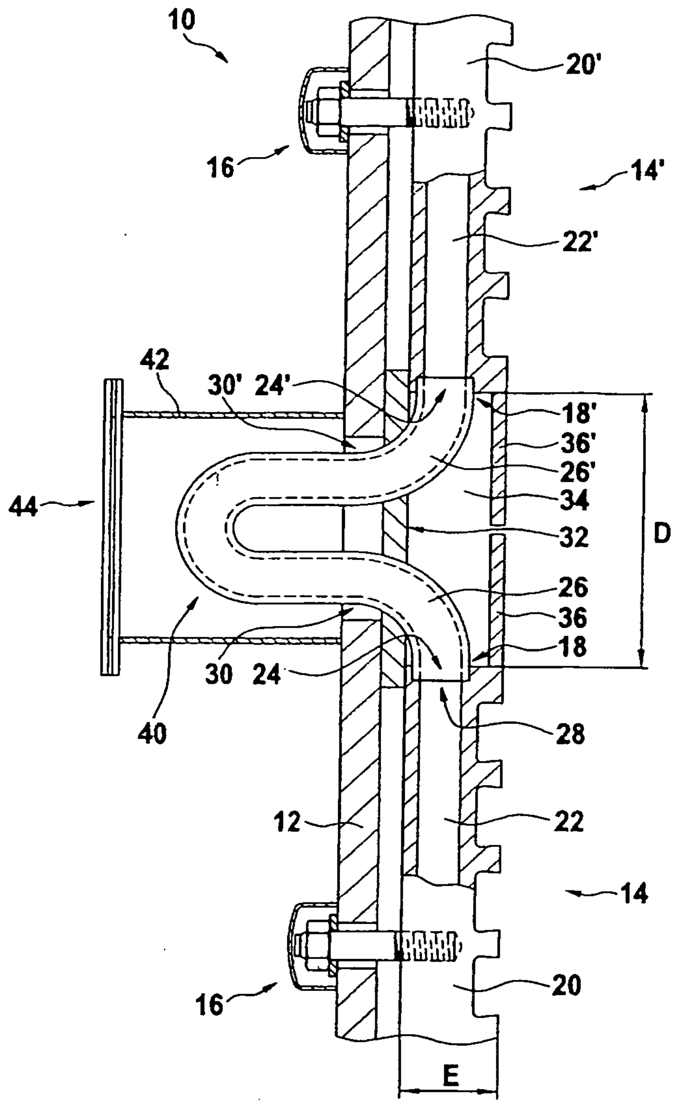

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Fig. 2

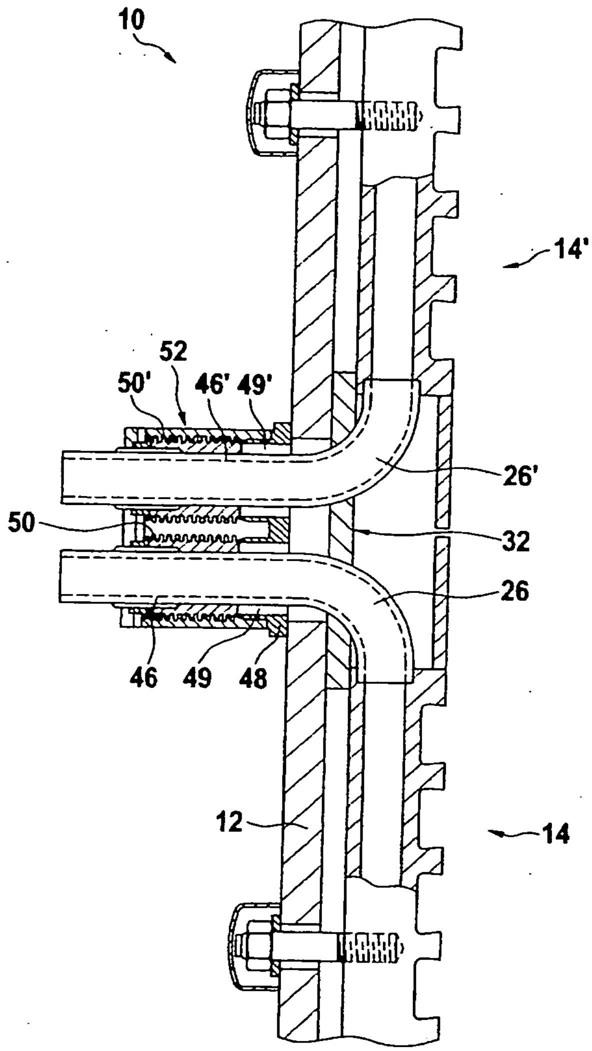

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Fig. 3

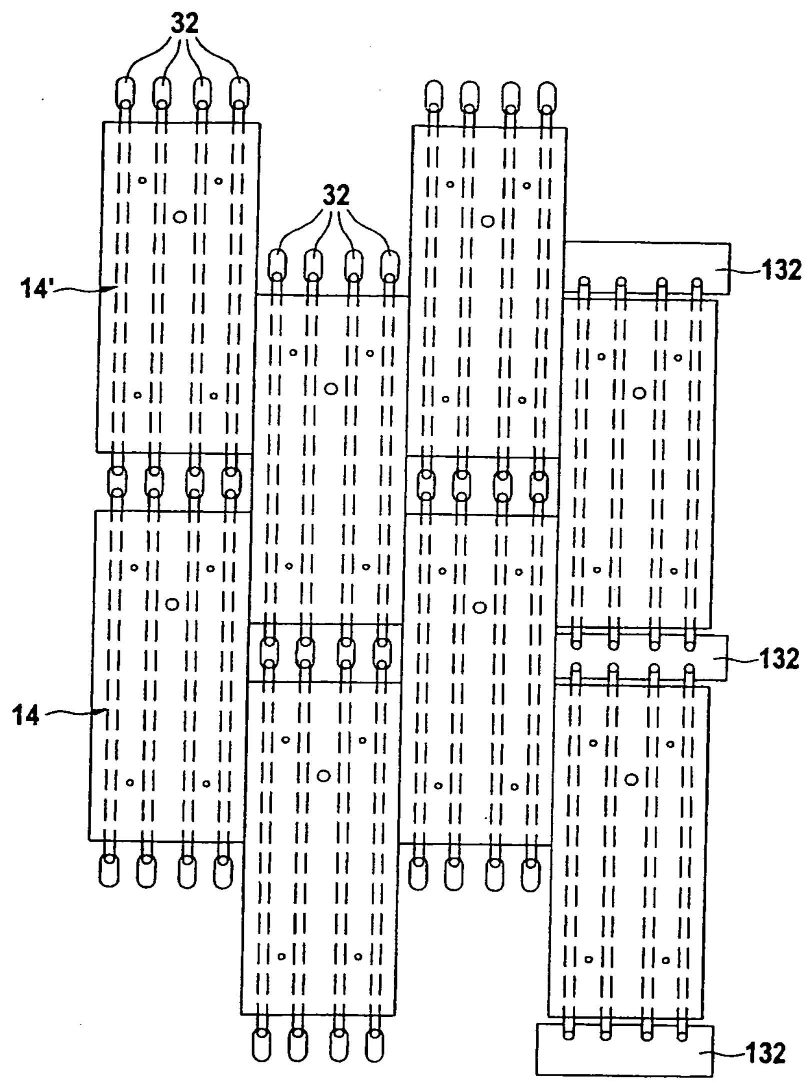

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Fig. 4

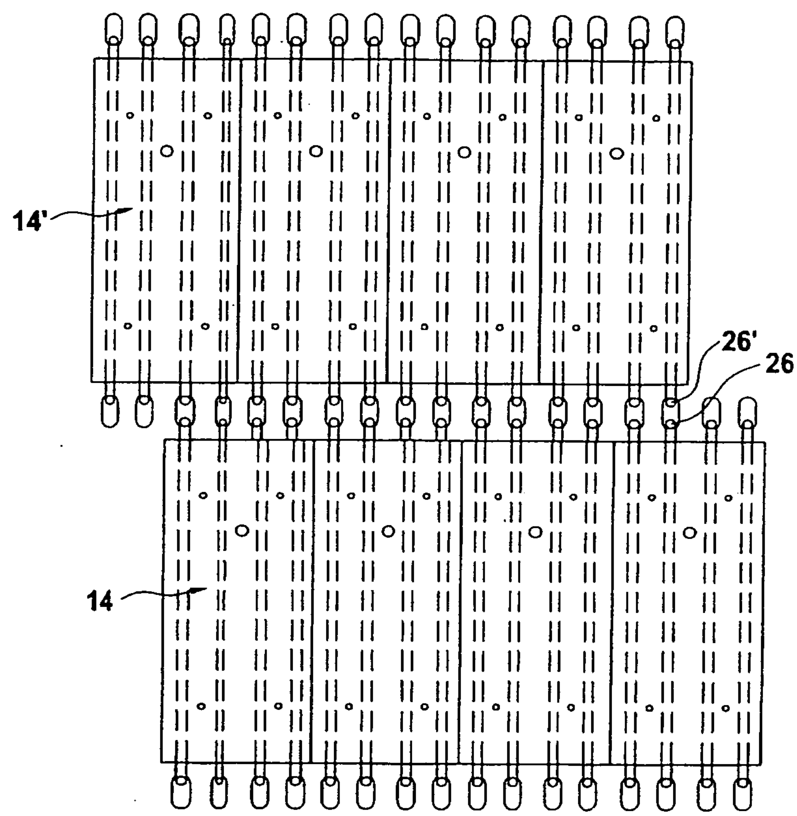

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Fig. 5

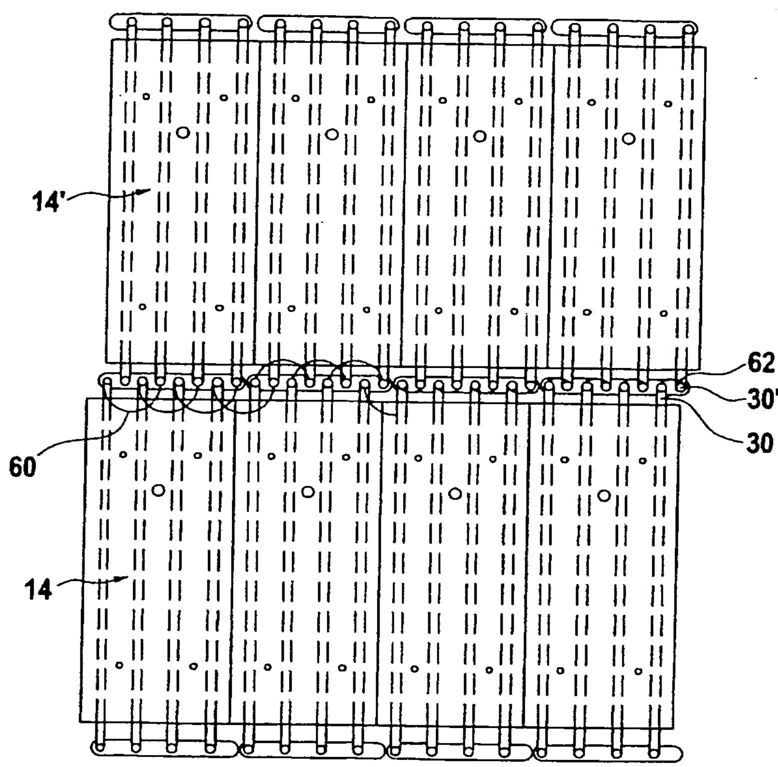

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Fig. 6

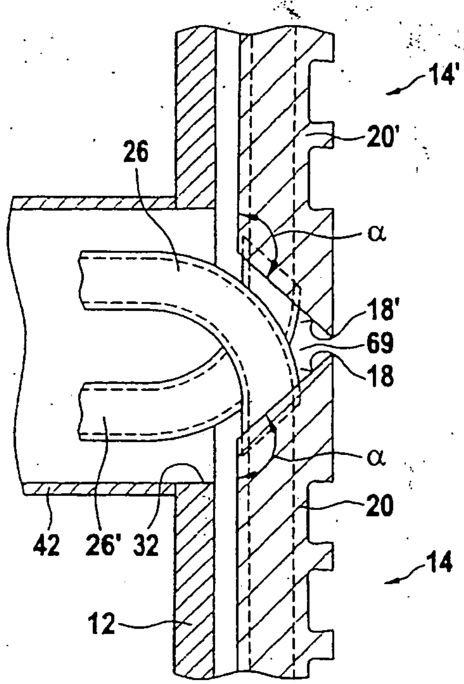

Fig. 7

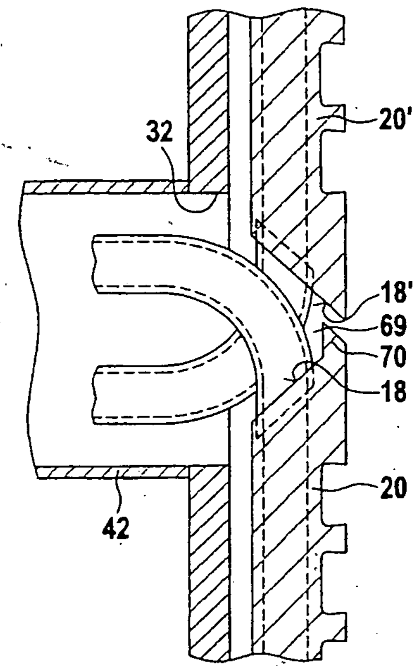

Fig. 8

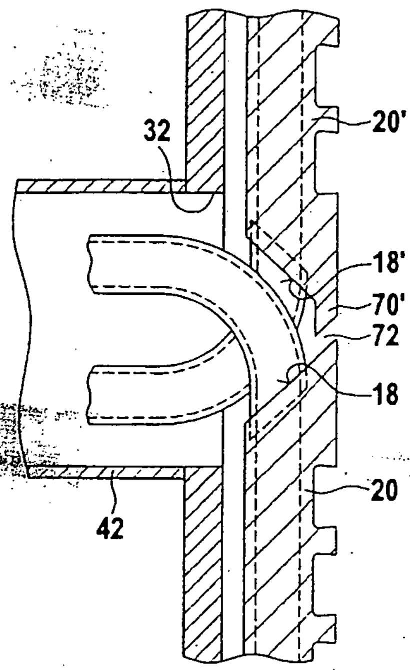

Fig. 9

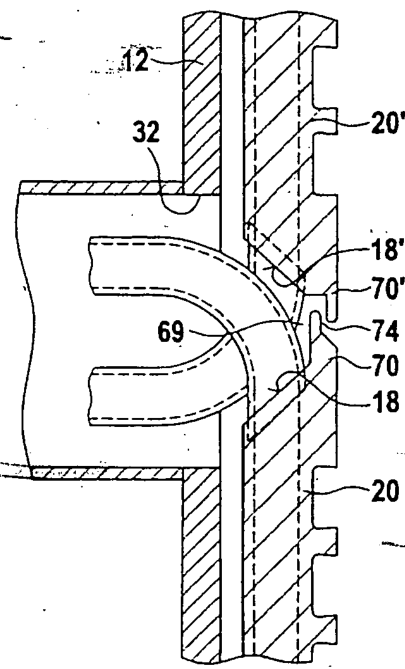

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Fig. 10

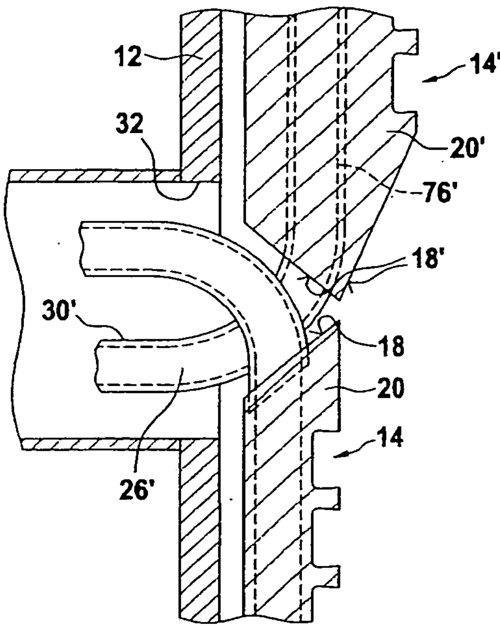

Fig. 11

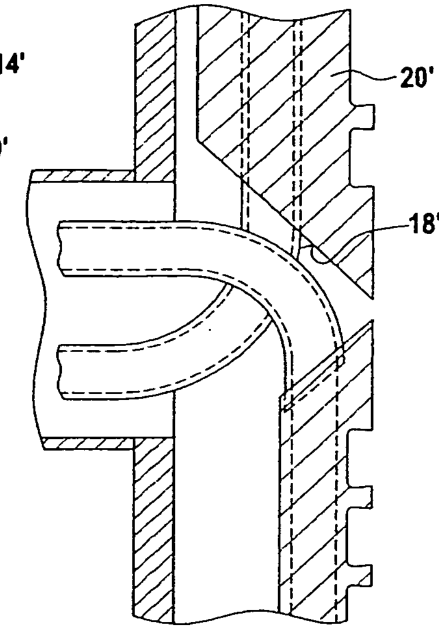

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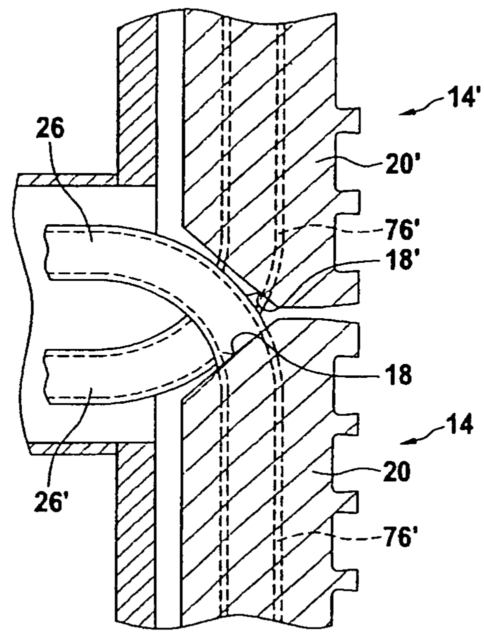
Fig. 12



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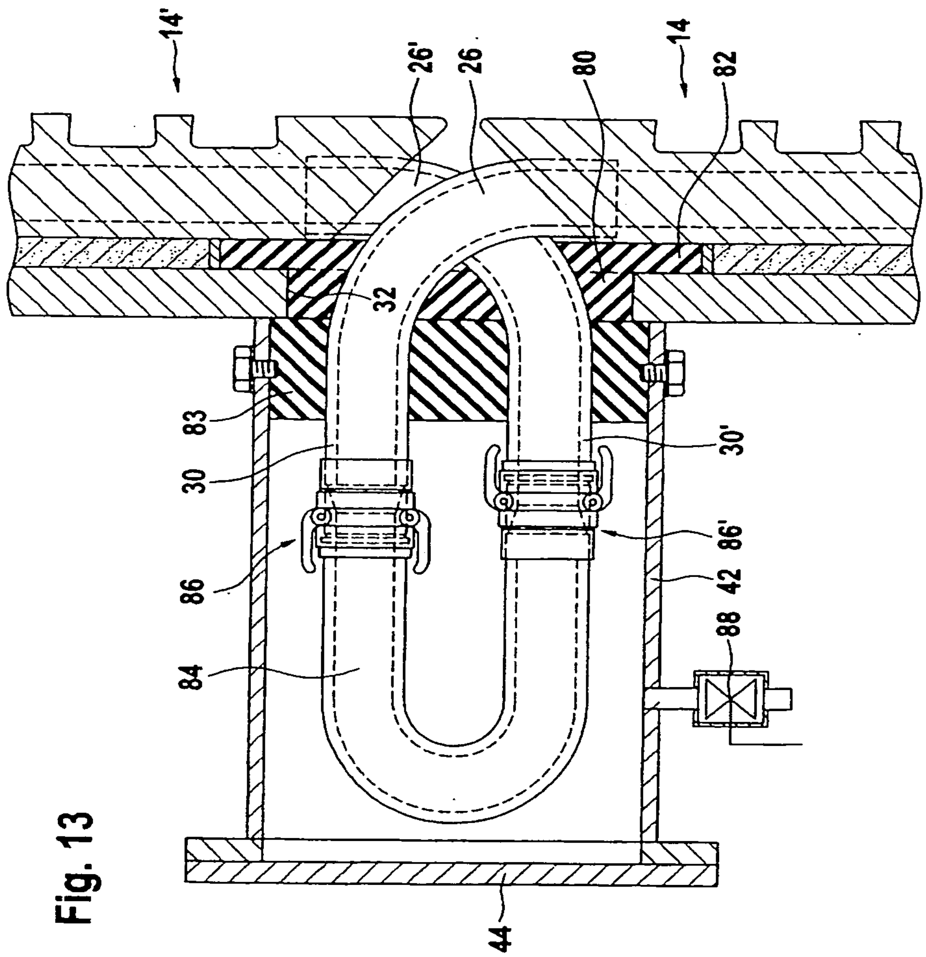

Fig. 13

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Fig. 14

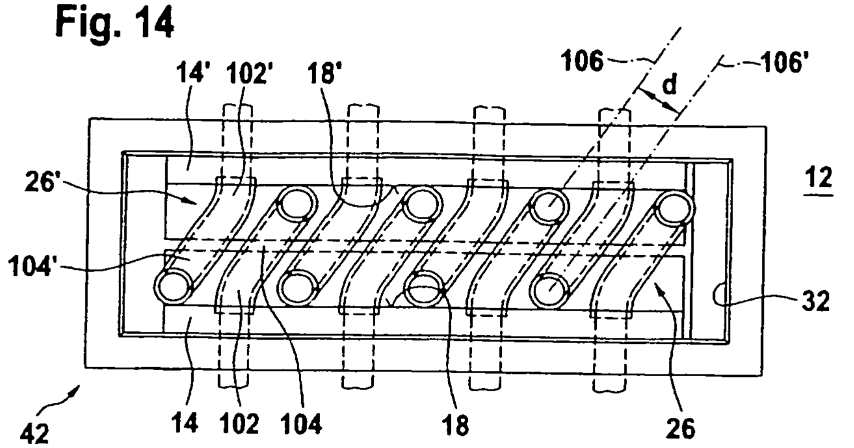

Fig. 15

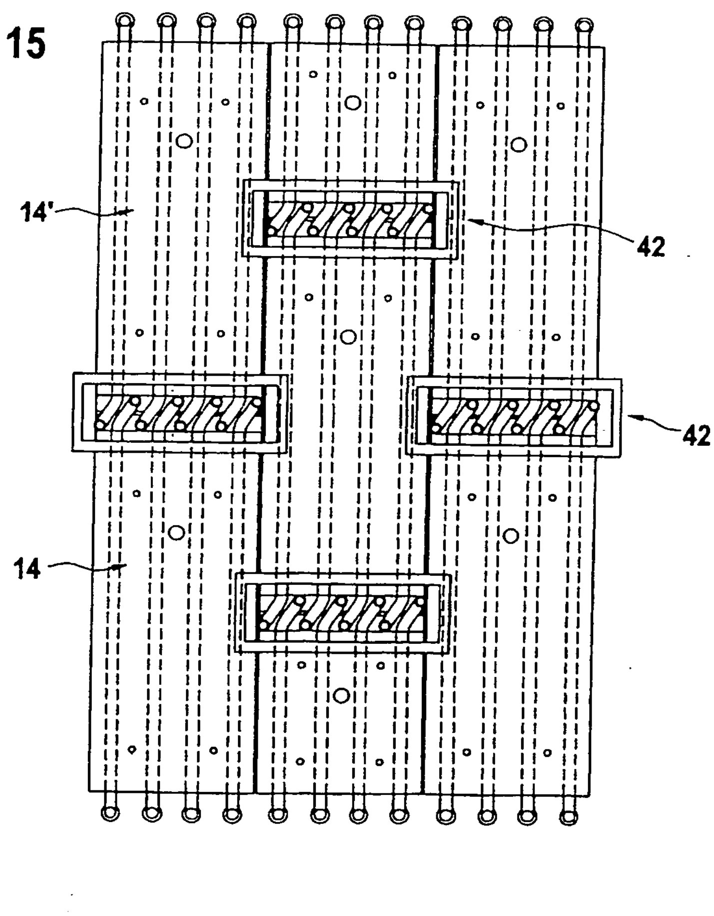

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Fig. 16

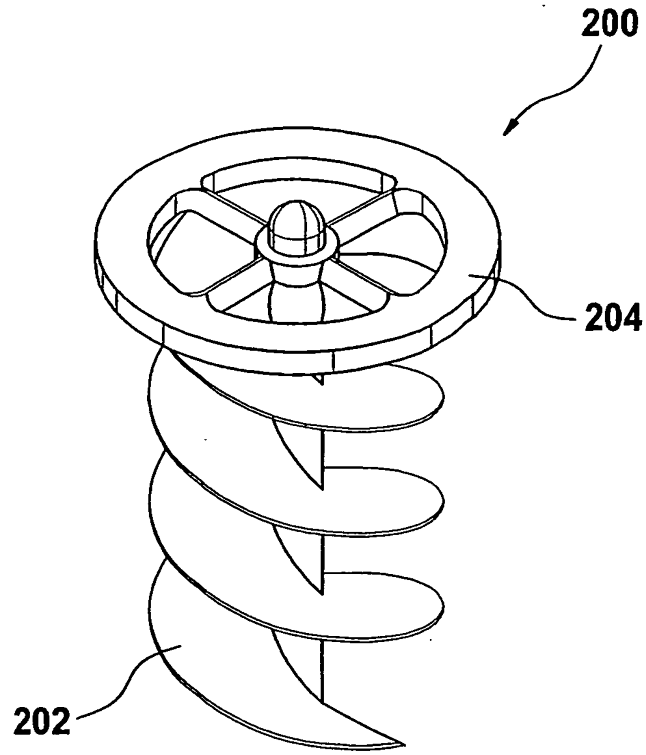

Fig. 17